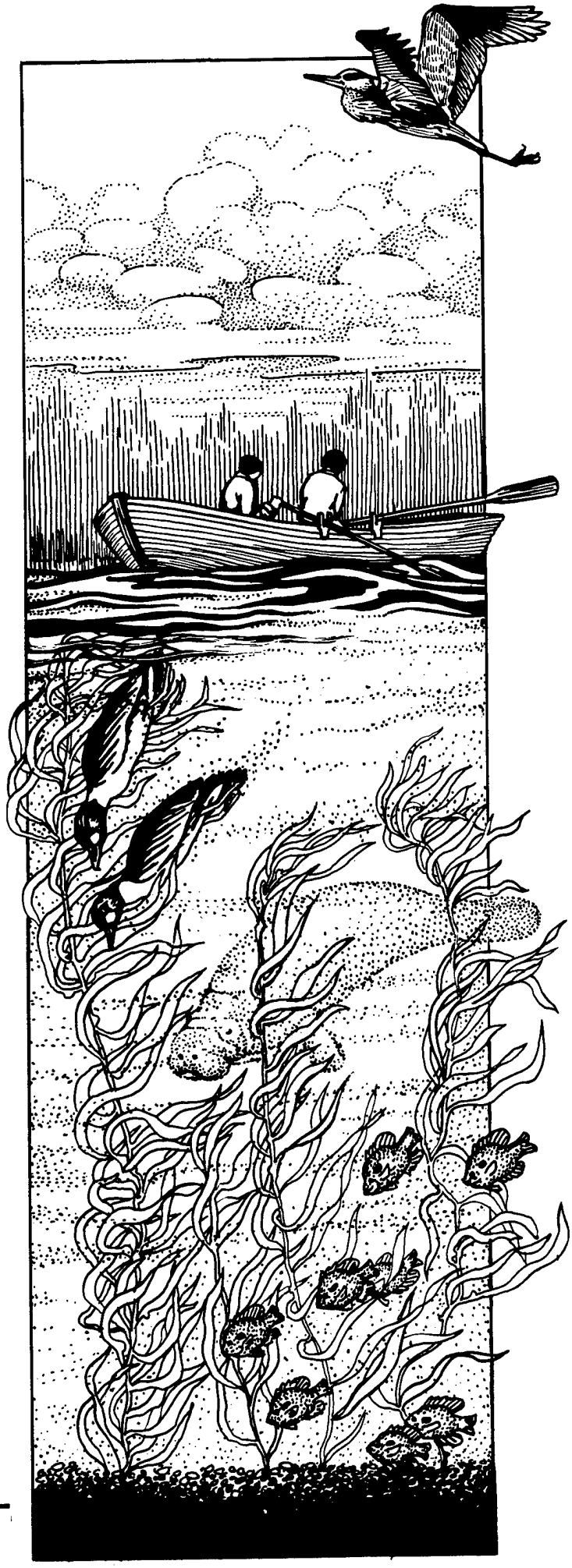
Biological Report 22
May 1994

# Recreational-boating Disturbances of Natural Communities and Wildlife: An Annotated Bibliography







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# Recreational-boating Disturbances of Natural Communities and Wildlife: An Annotated Bibliography

By

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# Contents

# Recreational-boating Disturbances of Natural Communities and Wildlife: An Annotated Bibliography

by

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**Abstract.** The increase in water-based recreation since 1972 created a serious compatibility issue for wildlife refuges. Land managers are challenged with integrating acceptable levels of recreational boating with the intended purpose of the refuge system. As conflicts between boating and resource protection escalate, there will be an increasing need for information on waterfowl flush and flight distances, zoning and buffer recommendations, and the disturbance reaction by different taxonomic groups. This bibliography contains 111 annotations on a wide array of boating disturbances. The citations are useful references for land managers who must determine acceptable levels of water-based recreation. An author and subject index are provided.

**Key words:** Bibliography, boating, buffers, disturbance, energy expenditure, flight distance, flush distance, wildlife, zoning.

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Recreational boating on inland waters in the United States has increased drastically since the early 1970's and is recognized as one of the more common forms of waterfowl disturbance (Korschgen and Dahlgren 1992). If this trend of increasing water-based recreation continues unabated, more restrictive boating regulations may be required to mitigate the threats to certain wildlife populations.

A fundamental problem for land managers is the need to integrate human uses with the conservation of natural communities and wildlife (Curtain 1993). Recreational boating is one such compatibility issues that has generated much debate and, in one instance, resulted in a lawsuit that directed the U.S. Fish and Wildlife Service to restore the Ruby Lake National Wildlife Refuge to its primary purpose as an inviolate sanctuary (Bouffard 1992).

This bibliography provides land managers with an easy-to-use reference of the disturbance effects of recreational boating. Managers can use this bibliography to determine levels at which recreational boating is compatible with the intended purpose of wildlife refuges.

An extensive list of papers was examined to include bibliographic entries on a wide array of boating disturbances. Bibliographic entries consist of technical and semitechnical published articles, books, government agency publications, theses, and dissertations. Disturbances from the sights or sounds of motorized boats comprise more than 60% of the entries. Non-motorized boating disturbances (i.e., sailboats, canoes, kayaks, rowboats, etc.) were mentioned in approximately 30% of the papers. Also included are citations on the effects of boating on turbidity, pollution, and the physical disturbance of aquatic plants that relates to habitat degradation. Unpublished works are included for completeness but identified with asterisks.

Effects of commercial navigation are not covered in this bibliography. The passage of commercial vessels affects aquatic organisms, such as freshwater mussels (Mollusca: Unionidae), through changes in water velocity, direction of flow, and turbidity. Although these impacts are recognized as

serious concerns, the scope of this bibliography was limited to recreational boating. For information on the effects of commercial navigation refer to P. A. Vohs, I. J. Moore, and J. S. Ramsey (1993. A critical review of the effects of turbidity on aquatic organisms in large rivers. Report by Iowa State University, Ames, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, unpublished).

When possible, the author's original abstract or summary was used in the bibliography (denoted as "author's abstract"). Some abstracts were modified for clarity or brevity (denoted as "from author's abstract"). Some annotations are not abstracts of the reports but my summaries of the relevant portions of the publications (denoted as "DLY").

The following databases were searched for keywords and titles on boating disturbance: *Wildlife Review* and *Fisheries Review* (NISC-Disc, 1971–January 1993), *Wildlife Worldwide* (NISC-Disc, 1935–May 1993), *Water Resources Abstracts* (NISC-Disc, 1967–June 1993), DUCKDATA (by K. J. Reinecke, National Biological Survey, Vicksburg, Mississippi), and *Waterbirds of Puget Sound* (U.S. Fish and Wildlife Service, Field Office, Olympia, Washington). Also searched were databases from U.S. Fish and Wildlife Service libraries, the Upper Mississippi River Conservation Committee (Rock Island, Illinois), the Fish and Wildlife Reference Service (Dingell-Johnson and Pittman-Robertson reports), and the Research Bibliographic Database of the National Biological Survey (T. J. Cortese, Information Transfer Center, Fort Collins, Colorado).

A primary source of information was an annotated bibliography on anthropogenic disturbances of waterfowl (Dahlgren and Korschgen 1992) and an annotated bibliography on human–wildlife interactions (Boyle and Samson 1983). The cited-literature sections of the papers in the bibliographies provided many more pertinent publications.

I attempted to locate as many papers as possible with data about flush distances (i.e., distance to which an animal can be approached before it flees), flight distances (i.e., distance an animal flees from a disturbance), zoning and buffer recommendations, and disturbance reactions of different taxonomic groups. However, quantifiable data in these areas were rare. Consequently, it would be difficult to draw general conclusions from this collection of citations, which indicates much work remains to be done on this issue.

Support for this project came in part from Robert Shallenberger, Chief, Division of Refuges, U.S. Fish and Wildlife Service.

## Cited Literature

Bouffard, S. H. 1982. Wildlife values versus human recreation: Ruby Lake National Wildlife Refuge. Transactions of the North American Wildlife and Natural Resources Conference 47:553–558.

Boyle, S. A., and F. B. Samson. 1983. Nonconsumptive outdoor recreation: an annotated bibliography of human–wildlife interactions. U.S. Fish and Wildlife Service Special Scientific Report—Wildlife 252. 113 pp.

Curtain, C. G. 1993. The evolution of the U.S. National Wildlife Refuge System and the doctrine of compatibility. Conservation Biology 7(1):29–38.

Dahlgren, R. B., and C. E. Korschgen. 1992. Human disturbances of waterfowl: an annotated bibliography. U.S. Fish and Wildlife Service Resource Publication 188. 62 pp.

Korschgen, C. E., and R. B. Dahlgren. 1992. Human disturbances of waterfowl: causes, effects, and management. U.S. Fish and Wildlife Service Fish and Wildlife Leaflet 13.2.15. 8 pp.

# Annotated Bibliography on Recreational-boating Disturbances of Natural Communities and Wildlife[1]

1. ÅHLUND, M., AND F. GÖTMARK. 1989. Gull predation on eider ducklings (*Somateria mollissima*): effects of human disturbance. Biological Conservation 48:115–127.

   Gull predation on eider (*Somateria mollissima*) ducklings in an archipelago on the west coast of Sweden is described. Both gull encounter rate and gull predation rate were 200–300 times higher on creches disturbed by boats than on undisturbed creches. Near islands with nesting gulls, intense boating may severely affect fledgling production by ducks. The results suggest that boating should be restricted in important duckling rearing areas. Boats may be allowed to pass breeding islands but should not remain within 50–100 m of the protected islands. [from authors' abstract]

2. AMES, P. L., AND G. S. MERSEREAU. 1964. Some factors in the decline of the osprey in Connecticut. Auk 81:173–185.

   The authors document that eggs are lost from ground nests of ospreys (*Pandion haliaetus*) because motorboats speed along the Great Island creeks in close proximity to the nests. The incubating ospreys attempted to escape discovery by remaining on the nest as long as possible. In response to the rapid approach of a boat, these ospreys flushed directly from the incubation position without first standing up. Eggs were dragged from the nest or broken by the birds' feet. Ospreys do not roll eggs back into the nests, even when the eggs are in plain sight. [DLY]

3. ANDERSON, J. M. 1978. Protection and management of wading birds. Pages 99–103 *in* A. Sprunt, IV, J. C. Ogden, and S. Winckler, editors. Wading birds. National Audubon Society Research Report 7.

   The National Audubon Society anchored a boat approximately 100 m from a colony of roseate spoonbills (*Ajaia ajaja*) and observed the birds without causing disturbance. The study revealed that during the nesting season, roseate spoonbills are extremely wary of human disturbance, and the intensity of this wariness varies by the nesting-cycle stage. [DLY]

4. ATKINSON-WILLES, G. 1969. Wildfowl and recreation: a balance of requirements. British Water Supply 11:5–15.

   Addressed is wildfowl conservation on British reservoirs. The integration of wildfowl conservation and recreation are discussed at length. Three categories of water recreation are listed: sailing; canoeing; and water-skiing, speed-boating, and hydroplaning. Sailing poses greater problems than the other activities because the demand for sailing facilities is increasing, the types of water bodies required for sailing are preferred by waterfowl, and the degree of disturbance exceeds the tolerance of most species of ducks. Some form of segregation is essential. Canoes, punts, and rowboats, because of their shallow draughts, are able to penetrate farther into shallows and thereby add to the disturbance by sailing craft. [DLY]

5. BAMFORD, A. R., S. J. J. F. DAVIES, AND R. VAN DELFT. 1990. The effects of model power boats on water birds at Herdsman Lake, Perth, Western Australia. Emu 90:260–265.

   The study shows that the use by waterbirds of those parts of Herdsman Lake used for racing model power boats remained at a level comparable with that of other parts of Herdsman Lake. We consider that the racing of model power boats, at its present levels of intensity and frequency, is not detrimental to waterbirds in the long term. On days when model boats were using the lake, some species vacated the lake, some moved to other parts of the lake and some sheltered in rushes while model boat racing was in progress. Numbers of waterbirds returned to pre-boating levels once the boats left. [authors' abstract]

6. BARTELT, G. A. 1987. Effects of disturbance and hunting on the behavior of Canada goose family groups in eastcentral Wisconsin. Journal of Wildlife Management 51:517–522.

   The author's objectives were to evaluate the cohesiveness of family groups of Canada geese

[1] Asterisks indicate unpublished reports.

(*Branta canadensis*) in a fall-migration area and to determine the effects of hunting and of disturbing roosting sites on the behavior of family groups of Canada geese. Disturbance consisted of intentional disturbances of geese in roosting areas with airboats at the Horicon National Wildlife Refuge and unintentional disturbances by airboats and helicopters used to collect carcasses during an avian cholera outbreak. This study revealed that disturbance on roosting sites may decrease the cohesiveness of family groups and increase hunting mortality. If dispersal techniques are used, the mortality of family members must be expected to increase. [DLY]

7. BATTEN, L. A. 1977. Sailing on reservoirs and its effects on water birds. Biological Conservation 11:49–58.

   Addressed is the increasing pressure to develop areas in England for water-based recreation and its effects on waterbird populations. Recommendations to minimize these disturbances are discussed. Waterbird populations may increase if sections of a reservoir are off limits to boat traffic. Sailing can disturb birds to such a degree that the energy expenditure from disturbance makes the lake an inefficient feeding site. The minimum distance birds allow sailing craft to approach suggests that larger flocks are more wary. Screening vegetation on the banks and large vegetated rafts may separate a reservoir into two sections: a refuge section for undisturbed nesting and foraging and an area for the pursuit of recreational activities. [DLY]

8. BAUER, H. G., H. STARK, AND P. FRENZEL. 1992. Disturbance factors and their effects on water birds wintering in the western parts of Lake Constance. Der Ornithologische Beobachter 89:81–91.

   From October to April 1989–90 and 1990–91, wintering waterbirds and all possible disturbance factors were simultaneously recorded at three study sites in the western part of Lake Constance. Since earlier studies, the number of disturbances in the Ermatingen Basin increased, which was mainly due to open boats (canoes, rowboats). The results underline a general tendency towards an increase in the use of the lake for human recreation during these months. In Constance Bay (which is of great ecological importance for wintering goldeneye [*Bucephala* sp.]), the population is decreasing significantly as the number of boats increases. In general, the pressure on wintering waterfowl in all three study sites reached such a high degree that it is of great importance to establish larger protected areas, to stop water sports and angling from October to March, and to impose a permanent ban on hunting. [from English summary of authors' German abstract]

9. BEHREND, D. F., AND R. A. LUBECK. 1968. Summer flight behavior of white-tailed deer in two Adirondack forests. Journal of Wildlife Management 32:615–618.

   The flight behavior of white-tailed deer (*Odocoileus virginianus*) in summer was studied in two areas—one when deer were hunted and one where deer were not hunted—in the Adirondack Mountains of northern New York. Antlered and antlerless deer ran and held their tails up in flight more often along the roadsides than around the lake, perhaps indicating greater sensitivity to approaching vehicles than to approaching canoes. [DLY]

10. BELANGER, L., AND J. BEDARD. 1990. Energetic cost of man-induced disturbance to staging snow geese. Journal of Wildlife Management 54:36–41.

    The energetic consequences of snow goose (*Chen caerulescens*) responses to disturbances were examined. Disturbance is detrimental to staging geese only if it reduces energy intake so much that it cannot be compensated by either increasing the rate of food intake during undisturbed periods or by avoiding disturbance by nighttime feeding. More than 2.0 disturbances/h may cause an energy deficit that no compensatory behavior mechanism (e.g., feeding at night) can counterbalance. The authors concluded that anthropogenic disturbances can have significant energetic consequences for staging greater snow geese in fall and that a comprehensive understanding of energetic requirements of greater snow geese on their staging grounds in relation to human disturbance is essential for optimum management. [DLY]

11. BELANGER, L., AND J. BEDARD. 1989. Responses of staging greater snow geese to hu-

man disturbance. Journal of Wildlife Management 53:713–719.

The effects of human disturbance on staging greater snow geese (*Chen caerulescens atlantica*) in spring and in fall in the Montmagny Bird Sanctuary, Quebec, 1985–87, are addressed. The causes of disturbances were classified as anthropogenic, natural, or unidentified. Anthropogenic disturbances included passages of ferry boats, small yachts, and motorboats. Transportation, particularly low–flying aircraft, caused 45% or more of all disturbances in spring and fall. More than 2.0 disturbances/h decreased the mean number of geese in the sanctuary by 50% on the next day. Disturbance could affect the geese's activity budgets, distribution, and abilities to store fat reserves for migration and breeding. Excessive disturbance could also disrupt pair and family bonds and induce mortality. [DLY]

12. BOUFFARD, S. H. 1982. Wildlife values versus human recreation: Ruby Lake National Wildlife Refuge. Transactions of the North American Wildlife and Natural Resources Conference 47:553–558.

Described are the U.S. Fish and Wildlife Service's attempts to manage recreation and wildlife conflicts on the Ruby Lake National Wildlife Refuge, where recreational boating grew from low use and little conflict with wildlife to heavy use and substantial disturbance of nesting waterfowl. Ninety percent of the visits to the refuge during the waterfowl breeding season were for angling and 65% of the visits involved fishing from boats. Regardless of motor size, courting canvasback (*Aythya valisineria*) and redhead (*Aythya americana*) pairs flushed at an average of nearly 271 m from any boat. Nesting canvasbacks and redheads flushed at an average of 35 m and flew at least 100 m from the disturbance. Birds that were repeatedly flushed from their nests by boating disturbance abandoned the nests. In addition, boats dispersed broods and forced them into less desirable habitats. Boating also damaged habitat. Boat propeller action can remove all vegetation, cause a decline in plant species composition, and seriously reduce submergent vegetation. The loss of aquatic vegetation, compounded by wakes from larger boats, caused bank erosion and siltation in some areas. This was especially prevalent in ponds where people water-skied. [DLY]

13. BOYLE, S. A., AND F. B. SAMSON. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110–116.

Information on the effects of nonconsumptive outdoor recreation on wildlife is evaluated. Wildlife is affected through sight and sound of recreationists, pollution from motorized boats, and recreational facilities. Waterfowl exhibit behavioral changes and move to less disturbed areas in response to boating. To determine biological impacts on certain species, changes in wildlife behavior must be critically examined. Some species are more sensitive to disturbance than others because of colonial behavior, unique breeding patterns, restricted distribution, or rigid habitat requirements. To set priorities, managers must determine the effects of disturbances by species, by type of recreational activities, by disturbance intensity, and by time of the annual cycle of the birds. [DLY]

14. BOYLE, S. A., AND F. B. SAMSON. 1983. Nonconsumptive outdoor recreation: an annotated bibliography of human–wildlife interactions. U.S. Fish and Wildlife Service Special Scientific Report—Wildlife 252. 113 pp.

This is an annotated bibliography of interactions between wildlife and humans participating in nonconsumptive outdoor recreation. The 536 citations are of books, articles, government publications, organization reports, theses and dissertations, and selected federal aid reports written between 1950 and 1980 and are primarily about terrestrial vertebrates of North America. [from authors' abstract]

15. BRATTON, S. P. 1990. Boat disturbance of Ciconiiformes in Georgia estuaries. Colonial Waterbirds 13:124–128.

The data in this paper imply *Ciconiiformes* may experience more difficulty habituating to boat traffic in some habitats than in others. As the passing distance approached 60 m, the percentage of flushed birds approached zero in all routes. At typical passing distances of small boats (15 to 40 m), birds in the estuaries were more likely to flush than birds on the shore. [DLY]

16. BROWN, P. W., AND M. A. BROWN. 1981. Nesting biology of the white-winged scoter. Journal of Wildlife Management 45:38–45.

The nesting biology and productivity of white-winged scoters (*Melanitta fusca deglandi*) were studied in Saskatchewan and Alberta. The authors note that white-winged scoters are easily disturbed by human interference such as recreational boating. The establishment of refuges and boating restrictions in areas preferred by breeding scoters may help maintain local populations. [DLY]

*17. BUCKLEY, P. A., AND F. G. BUCKLEY. 1976. Guidelines for protection and management of colonially nesting waterbirds. North Atlantic Regional Office, National Park Service, Boston, Massachusetts. 54 pp.

This document offers guidelines for protecting and managing colonially nesting waterbirds on refuges and in parks. Recommended boating restrictions include: (1) post colonies on islands for the proper period; (2) place signs in the water 50 m from the shore of the island (boats should be kept 200 m from occupied islands); (3) remove the signs as soon as the birds depart the island. [DLY]

18. BUEHLER, D. A., T. J. MERSMANN, J. D. FRASER, AND J. K. D. SEEGAR. 1991. Effects of human activity on bald eagle distribution on the northern Chesapeake Bay. Journal of Wildlife Management 55:282–290.

The relation between bald eagle (*Haliaeetus leucocephalus*) distribution and human activity on the northern Chesapeake Bay shoreline during 1985–89 was determined by the authors. The survey route was divided into 250-m segments. Few eagles used shoreline segments with boats or nearby pedestrians ($P<0.001$). Only 360 of 2,532 segments (14.2%) were without human activity or shoreline development. Eagles flushed at greater distances from approaching boats in winter than in summer (mean distance of 264.9 m vs. 175.5 m; $P = 0.001$), and this distance did not differ between adults and immature eagles (mean distance of 203.7 m vs. 228.6 m; $P = 0.38$). [from authors' abstract]

19. CONSERVATION COMMITTEE REPORT. 1978. Management of National Wildlife Refuges in the United States: its impacts on birds. Wilson Bulletin 90:309–321.

Documented are six problems associated with management of national wildlife refuges by the U.S. Fish and Wildlife Service. Boating is listed as one of the recreational activities that defeat the original purpose of the refuge system. The obvious and documented impacts of high-speed boating are shoreline degradation, disruption of nesting and feeding areas and subsequent loss of production of young, and displacement of waterbirds. These problems, especially the loss of production of young in canvasbacks (*Aythya valisineria*) and redheads (*Aythya americana*), are pronounced on the Ruby Lake National Wildlife Refuge, Nevada, and caused the preparation of an environmental impact statement on the effects of boating on this refuge. The authors recommend public recreation not be given preference over stated objectives of a refuge, non-human use areas be an integral part of the refuge concept and be meshed with the objectives of each refuge, and public visitation be encouraged on portions of refuges with adequate staffing and suitable open hours. [DLY]

20. COOKE, A. S. 1987. Disturbance by anglers of birds at Grafham Water. ITE Symposium 19:15–22.

The disturbance of waterbirds from angling are discussed. At this British reservoir, low levels of sailing caused little disturbance because sailing was done mainly in deep water, which waterfowl avoided. The shallow, sheltered bays that waterbirds prefer are heavily used by anglers who cause considerable disturbance of the birds. The most sensitive species to angling disturbance were grey herons (*Ardea cinerea*), common pochards (*Aythya ferina*), and gadwalls (*Anas strepera*). [DLY]

21. COULTER, M. W., AND W. R. MILLER. 1968. Nesting biology of black ducks and mallards in northern New England. Vermont Fish and Game Department Bulletin 68. 74 pp.

The paper principally presents results from the analysis of nesting activities of black ducks (*Anas rubripes*) and mallards (*A. platyrhynchos*) in Maine and Vermont. Black ducks became especially wary after they were flushed from their nests by a passing boat. Having been flushed by a boat once, black

duck hens left their nests whenever a boat came into the vicinity. Thus, boating that does not normally cause other species to flush from nests, caused repeated departures from nests by black ducks. [DLY]

22. CRONAN, J. M., JR. 1957. Food and feeding habits of the scaups in Connecticut waters. Auk 74:459–468.

    The food and feeding habits of the greater scaup (*Aythya marila*) are described in detail in this paper. It is also noted that the scaup's feeding activities are disturbed by human activity such as motorized boating. [DLY]

23. CRYER, M., N. W. LINLEY, R. M. WARD, J. O. STRATFORD, AND P. F. RANDERSON. 1987. Disturbance of overwintering wildfowl by anglers at two reservoir sites in South Wales. Bird Study 34:191–199.

    The reclamation of natural wetlands for agricultural and for urban development has decreased the feeding areas for waterfowl and caused large-scale congregations of waterfowl on reservoirs and on the remaining natural sites. These aggregations often create conflicts between conservation and recreational pursuits. The Llandegfedd Reservoir in South Wales is one of the most important inland sites for overwintering waterfowl in South Wales. Sailing during and outside the angling season is so disruptive at Llandegfedd that entire waterfowl populations desert the area. [DLY]

24. CURTAIN, C. G. 1993. The evolution of the U.S. National Wildlife Refuge System and the doctrine of compatibility. Conservation Biology 7:29–38.

    Presented is a review of the history and evolution of the United States National Wildlife Refuge System. The refuge system is guided by the doctrine of compatibility, which permits only uses that are "compatible with the purposes for which the refuge was established." Memoranda and documents from the last 100 years were examined and key refuge personnel were interviewed to understand the historical basis for current refuge policies. Through time, the refuge system shifted from strict protection of wildlife to integrating public uses of refuges. The doctrine of compatibility facilitated public use of wildlife refuges. Recreation and resource use increasingly interfere with the purposes for which refuges were established. A legislative solution may be needed to ensure that refuges are protected and remain viable reserves for wildlife and natural communities. [from author's abstract]

25. DAHLGREN, R. B., AND C. E. KORSCHGEN. 1992. Human disturbances of waterfowl: an annotated bibliography. U.S. Fish and Wildlife Service Resource Publication 188. 62 pp.

    The expansion of outdoor recreation greatly increased the interaction between the public, waterfowl, and waterfowl habitat. The effects of these interactions on waterfowl habitats are visible and obvious, whereas the effects of interactions that disrupt the normal behavior of waterfowl are subtle and often overlooked but perhaps no less harmful than destruction of habitat. Resource managers and administrators require information on the types, magnitude, and effects of disturbances from human contact with wildlife. This bibliography contains annotations for 211 articles with information about effects of human disturbances on waterfowl. Indexes are provided by subject or key words, geographic locations, species of waterfowl, and authors. [authors' abstract]

26. DRENT, R. H., AND C. J. GUIGUET. 1961. A catalogue of British Columbia sea-bird colonies. Occasional Papers of the British Columbia Provincial Museum 12:1–173.

    Disturbance of nesting seabird colonies increased with a rising number and changing type of boating. The number of high-speed power boats increased in the south-coast waters of British Columbia. The boaters stop at colonies to break the monotony of travel. The increased disturbances of seabird nesting colonies causes the loss of eggs and young. Northwestern crows (*Corvus caurinus*) quickly seize the opportunity to rob nests of eggs and young when human intruders frighten seabird hens from their nests. [DLY]

27. EDINGTON, J. A. 1980. Recreation and wildlife. Nature in Wales Newsletter pp. 10–16.

    The disturbance of overwintering wildfowl by sailing in England was examined. Because of its warm winters, England provides refuge for a disproportionately large fraction of western

Europe's waterfowl population. However, the recreational boom in the 1960's seriously threatened these British reservoirs as waterfowl refuges. Different segregation techniques based on time and space have been attempted at some reservoirs with a variety of results. Common goldeneyes (*Bucephala clangula*) are particularly sensitive to disturbance, flying up when sailing dinghies approached within 300–400 m. Common pochards (*Aythya ferina*), tufted ducks (*A. fuligula*), and mallards (*Anas platyrhynchos*) are reputedly less sensitive, tolerating the closer approach of sailing craft before flying and returning more readily when sailing stops at the end of the day. [DLY]

28. EDWARDS, R. W., AND D. V. BELL. 1987. The impact of angling on wildlife. Pages 161–166 *in* Proceedings of the 4th British Freshwater Fisheries Conference, 1–3 April 1985, University of Liverpool.

A review of the disturbance impacts of angling on wildlife in England is presented. The generally disturbing effects of recreational activities, such as boating and angling, on some bird species were recorded. Interactions between these activities are frequent. The authors suggest that wildlife areas free from disturbance on refuges be expanded during critical stages of overwintering and breeding. Interference of angling and other activities with breeding birds that nest along the margins of water-bodies needs further investigation. [DLY]

29. EINARSEN, A. S. 1965. Black brant, sea goose of the Pacific coast. University of Washington Press, Seattle. 142 pp.

This book on the black brant (*Branta bernicla nigricans*) includes a description of how boating continually molests geese seeking food in their usual places. During the 5 years of study, boats with outboard motors became so numerous that they course almost continuously on many feeding grounds that brants favor and make the areas untenable for the species. This is common from British Columbia to San Quentin Bay in northern Baja California. [DLY]

30. ERWIN, R. M. 1989. Responses to human intruders by birds nesting in colonies: experimental results and management guidelines. Colonial Waterbirds 12:104–108.

Colonies of nesting wading birds and seabirds were studied at coastal sites to determine distances at which birds flushed in response to human disturbance. The recommended buffer distance for colonies of least terns, royal terns (*Sterna antillarum* and *S. maxima*), and wading birds is 100 m. A distance of 200 m is recommended for colonies of common terns (*S. hirundo*) and skimmers (*Rynchops* spp.). Greater buffer distances are required before birds establish at a site. Closure signs should be erected at least 3 weeks before egg laying begins and should not be taken down before most young are fledged. Signs should be placed at 50-m intervals around the colony perimeter. [DLY]

*31. EVENSON, D., C. HOPKINS, AND G. MARTZ. 1974. Waterfowl and waterfowl hunting at Houghton Lake. Michigan Department of Natural Resources, Wildlife Division, Information Circular 171, Lansing. 7 pp.

The effects of food resources and disturbances by humans (hunting, fishing, boating, etc.) on the use of Houghton Lake by ducks and other water birds were determined. At least 85% of the disturbances involved boats and 53% of these were directly related to hunting. The authors concluded that each duck and each American coot (*Fulica americana*) was disturbed about 1.5 times/day during the 1972 hunting season. Disturbance rates were about 1.5 times greater on weekends than during the week. In spite of the disturbances in 1972, ducks never left the lake because of harassment. [DLY]

32. FRASER, M. W. 1987. Reactions of sea-ducks to windsurfers. British Birds 80:424.

The author briefly describes the reaction of common eiders (*Somateria mollissima*) to windsurfers along the coast of South Africa. Although eiders usually ignore dinghies, small sailboats, and engine-powered boats, the rapid approach of a windsurfer caused widespread panic among the flock. [DLY]

33. GARRAD, P. N., and R. D. HEY. 1987. Boat traffic, sediment resuspension and turbidity in a Broadland river. Journal of Hydrology 95:289–297.

Increasing levels of turbidity reported for parts of the Norfolk Broads over the last century have been attributed to algal growth. This paper demonstrates how the resuspension of bed sediments by a single moving boat is possible, and how the diurnal variation of boat traffic movement has distinct effects on patterns of suspended sediment concentration and hence turbidity. Control of boat speed and frequency thus has important implications for the management of turbidity levels in Broadland. [authors' abstract]

34. GARRAD, P. N., AND R. D. HEY. 1988. River management to reduce turbidity in navigable Broadland rivers. Journal of Environmental Management 27:273–288.

Levels of turbidity in the Norfolk Broads increased during the last century. Macrophytes subsequently declined from increased shading and thereby reduced the protection of river banks from erosion, particularly from boat wash. The diversity of fish stocks also declined with diminishing food resources. The turbidity is largely ascribed to algal blooms and secondarily to motorized boat traffic. The daily patterns of boat traffic are responsible for large diurnal variations in suspended sediment concentration and hence turbidity. Much of the boat-induced sediment remains in suspension until the next day, but the effect of boat traffic on turbidity is seasonal. Control of boat speed and frequency has important implications for the control of turbidity levels in Broadland and thus for the ecological and physical management of these waterways. [from authors' abstract]

*35. GOLDMAN, L. 1991. Regulatory protection of coastal nongame habitats. Pages 149–152 *in* D. P. Jennings, compiler. Proceedings of the Coastal Nongame Workshop, Southeast Region, 10–12 September, 1991. Gainesville, Florida. U.S. Fish and Wildlife Service and Florida Game and Fresh Water Fish Commission.

Boating in important waterbird habitat has increased in many areas. Disturbances from personal watercraft have been severe in coastal Florida and Alabama. Islands on which birds nest have been degraded by the use of personal watercraft. Federal laws and the processes and problems of enforcement are discussed. [DLY]

36. HARDMAN, J. A., AND D. R. COOPER. 1980. Mute swans on the Warwickshire Avon—a study of a decline. Wildfowl 31:29–36.

The authors studied the size and distribution of the mute swan (*Cygnus olor*) population in England. A long-term decline in breeding success in parts of the study area is thought to reflect deterioration of habitat from dredging for navigation and drainage. This and the increased boat traffic have reduced the areas of macrophytic vegetation. The reduction of vegetation could result in the greater availability of lead weights, which the swans may ingest. Lead poisoning is a major cause of mute swan mortality. [DLY]

37. HARTMAN, G. W. 1972. The biology of dump nesting in wood ducks. M.S. thesis, University of Missouri—Columbia. 66 pp.

During the study, wood ducks (*Aix sponsa*) flushed at distances of 137 m from excessively loud boats. Wood ducks swam away from quiet boats without flushing. A canoe was within 46 m before a pair moved away. Incubating hens tolerated boats within a few yards of a nest. However, on busy holiday weekends, desertions of nest boxes increased noticeably near popular angling spots. [DLY]

38. HAVERA, S. P., L. R. BOENS, M. M. GEORGI, AND R. T. SHEALY. 1992. Human disturbance of waterfowl on Keokuk Pool, Mississippi River. Wildlife Society Bulletin 20:290–298.

The extent of human disturbance of diving ducks on Keokuk Pool during spring and fall migration is described. Boating caused 78.5% of the disturbances in fall 1986, 73.1% in fall 1987, 58.9% in spring 1987, and 69.6% in spring 1988. Boating within approximately 450 m causes diving ducks to take flight. A minimum buffer zone of 450 m could protect rafting diving ducks from boating. Disturbances from boating caused waterfowl to fly farther than disturbances from barges. Based on the data collected during this study, establishment of an experimental refuge free of boating would potentially reduce daylight disturbance by about 91% during fall and by about 94% during spring at site 4 and by 78%

during fall and by 63% during spring at site 5. [DLY]

39. HILTON, J., AND G. L. PHILLIPS. 1982. The effect of boat activity on turbidity in a shallow Broadland river. Journal of Applied Ecology 19:143–150.

Measurements of water turbidity and of boat movements were made on a shallow Broadland river, the Ant, above and below Barton Broad. A model was used to predict water turbidities from typical boat movement patterns. This demonstrated that long-term buildup of boat-induced turbidity through the holiday season was unlikely and that most of the turbidity in and below Barton Broad on the river Ant was due to algae, not to boating activity. [from authors' abstract]

40. HULBERT, I. A. R. 1990. The response of ruddy shelduck *Tadorna ferruginea* to tourist activity in the Royal Chitwan National Park of Nepal. Biological Conservation 52:113–123.

In a study of the effect of tourist canoes on the distribution and daily activity of ruddy shelduck (*Tadorna ferruginea*) wintering on the River Rapti in Nepal, the number of ruddy shelduck was unaffected by the canoes. The average length of time a bird was disturbed each day was 11 min. This represented 2.6% of the time spent on total daily activities. Canoes filled with tourists on the downstream journey were responsible for 26% of the total time disturbed, but on the return journey, when the empty canoes were hauled back upstream, they were responsible for 74% of the total time disturbed. Disturbance, although very small, could be reduced further if the canoes returned in convoy on the northern side of the river. [author's abstract]

41. HUME, R. A. 1976. Reactions of goldeneyes to boating. British Birds 69:178–179.

Observations of the effects of boating disturbance on common goldeneyes (*Bucephala clangula*) were recorded at the Cannock Reservoir, Staffordshire, England. A sailboat within 350 m caused 60 goldeneyes to take flight and leave the area. A powerboat at a distance of 550 m caused a flock of goldeneyes to flush. The noise from the engine was inaudible to the observer. In an extreme case of wariness, a flock flushed when two cars towing boats drove by at a 350-m distance. [DLY]

42. JACKIVICZ, T. P., JR., AND L. N. KUZMINSKI. 1973. The effects of the interaction of outboard motors with the aquatic environment—a review. Environmental Research 6:436–454.

The effects of the compounds emanating from outboard-motor subsurface exhausts on water quality and aquatic biota are reviewed. The problems associated with bad water quality may include the formation of undesirable tastes and odors and the appearance of oily substances. Outboard-motor exhaust water can leave a toxic effect of oily substances in sufficiently high concentrations on fathead minnows (*Pimephales promelas*) and bluegills (*Lepomis macrochirus*), can taint the flesh of various fishes, and may affect the reproduction of fishes. A discussion of current research into the effects of outboard motors on the aquatic environment is presented. Recommendations for future research are given to broaden the understanding of the effects of outboard motors with the aquatic environment. [from authors' abstract]

43. JAHN, L. R., AND R. A. HUNT. 1964. Duck and coot ecology and management in Wisconsin. Michigan Department of Natural Resources Technical Bulletin 73. 119 pp.

Boating has become a major disturbance in Wisconsin. Reactions of waterbirds to human activities vary by the frequency and volume of a disturbance and by species. The authors classified breeding ducks and coots in Wisconsin according to the intolerances of human disturbance. Most tolerant are the blue-winged teal (*Anas discors*), the American coot (*Fulica americana*), the wood duck (*Aix sponsa*), and the mallard (*Anas platyrhynchos*). Least tolerant are the hooded merganser (*Lophodytes cucullatus*), the ring-necked duck (*Aythya collaris*), and the black duck (*Anas rubripes*). Breeding blue-winged teals and coots were observed in areas with a moderate volume of disturbance such as boat channels. These birds are seemingly among the last species to abandon suitable habitat as disturbance becomes excessive. Airboats easily invade shallow-water areas of most value

to waterfowl and pose a serious threat to waterfowl production in Wisconsin. [DLY]

44. JAHRSDOERFER, S. E., AND D. M. LESLIE, JR. 1988. Tamaulipan brushland of the Lower Rio Grande Valley of south Texas: description, human impacts, and management options. U.S. Fish and Wildlife Service Biological Report 88(36). 63 pp.

    This synthesis provides a single-source reference of a historical review, land-use planning, and management of brushland habitats and wildlife populations of the lower Rio Grande Valley. The adverse effects of boating in this area include turbulence, turbidity, cutting of vegetation by propellers, direct contact with river banks and riparian vegetation, visual and auditory disturbance of animals, and pollution from motors and sewage. [DLY]

45. JOHNSON, R. E. 1964. Fish and fowl. Pages 453–458 *in* J. P. Linduska, editor. Waterfowl tomorrow. U.S. Department of Interior, Fish and Wildlife Service. U.S. Government Printing Office, Washington, D.C.

    The implication of managing Willow Slough in Indiana for human recreation and for fishes and wildlife are presented. Anglers in boats and on the banks disturbed waterfowl. The author suggests the disturbance can be resolved by zoning certain water areas as waterfowl refuges. Another alternative is restricted angling during the nesting and brood-rearing seasons. [DLY]

46. JOHNSTONE, I. M., B. T. COFFEY, AND C. HOWARD-WILLIAMS. 1985. The role of recreational boat traffic in interlake dispersal of macrophytes: a New Zealand case study. Journal of Environmental Management 20:263–279.

    Many aquatic weeds reproduce only vegetatively, and controlling the dispersal of vegetative fragments of such macrophytes between lakes is a significant problem in aquatic-weed management. The authors analyze the dispersal of these plants and suggest measures to control their spread. Plant distribution was significantly associated with boating and angling, suggesting that dispersal is related to these activities. Boat inspections at 14 lakes revealed that 5.4% of the boats entering the lakes carried vegetative fragments of aquatic weeds and that 27% had come from other lakes. Boats leaving lakes, however, carried weed fragments only when the haul-out area was near weed beds, suggesting that weed control near haul-out areas would greatly reduce the probability of boat-mediated dispersal. A model for predicting the frequency of dispersal of macrophytes by recreational boat traffic is developed. For locally generated data, this model can help with management. [from authors' abstract]

47. KADEL, J. J., AND J. F. GORZELANY. 1993. Manatee surveillance during high speed powerboat races. Florida Scientist 56:23.

    The U.S. Fish and Wildlife Service and the U.S. Coast Guard developed guidelines for West Indian manatee (*Trichechus manatus*) surveillance during high-speed-watercraft events in Florida's coastal waters to minimize the risk of manatee/boat collisions. The Mote Marine Laboratory has conducted manatee surveillance for the Sarasota and Tampa races since 1985. Not only race boats, but increased traffic from boats of spectators increase hazards for manatees. Although manatees may leave the area because of increased boating, sightings were confirmed on or near the race courses during eight of the eleven surveyed events. In each case, specific protocols were followed, and the risk to the animals was minimized. Results indicate that regulatory agencies and race officials should consider historical manatee-sighting data for the selection of the date and the site for an event. [from authors' abstract]

48. KAHL, R. 1991. Boating disturbance of canvasbacks during migration at Lake Poygan, Wisconsin. Wildlife Society Bulletin 19:243–248.

    The frequency of disturbance and the limited daylight access to food resources documented in this study suggest that human disturbance is an important concern for the management of canvasbacks (*Aythya valisineria*). For all season-year periods combined, 216 disturbances to canvasbacks were observed, 94% (202) of which were from recreational boating. Disturbances in the spring may have a greater energetic impact on canvasback populations than disturbances in the fall. During spring on Lake Poygan, boating disturbance

contributed to the 48–53% of daylight hours that canvasbacks spent away from feeding areas. To alleviate boating disturbance in fall-staging areas, wildlife managers must address fishing and hunting. Alternative management may be establishing inviolate refuges, creating no-wake or nonmotorized boating zones, restricting fishing or hunting, and increasing public awareness. Inviolate refuges are the most effective but also the most controversial protection of the resource. Refuges should be at least 1.5–2.0 km by 1.5–2.0 km in size and encompass as much of a feeding area as feasible. No-wake zones or nonmotorized boating zones would reduce disturbance by lowering the speed of boats. [DLY]

49. KAISER, M. S., AND E. K. FRITZELL. 1984. Effects of river recreationists on green-backed heron behavior. Journal of Wildlife Management 48:561–567.

The authors' objective was to determine the behavior of green-backed herons (*Butorides striatus*) in relation to the intensity of recreational activity on the Ozark National Scenic Riverway. The green-backed heron is a common species in the eastern United States, and the authors suggest that it could serve as a potential indicator of recreation-related disturbance on lands such as the Ozark National Scenic Riverway. During this study, heron activity declined on three of the four survey routes when the use of canoes and boats on the main river channel increased. [DLY]

50. KELLER, V. E. 1989. Variations in the response of great crested grebes *Podiceps cristatus* to human disturbance—a sign of adaptation? Biological Conservation 49:31–45.

Great crested grebes (*Podiceps cristatus*) breeding on three small lakes in Switzerland with different intensities of recreation differed in their response to human disturbance. On lakes with recreation, they left their nests at shorter distances to approaching rowing boats, but covered their eggs less frequently than on an undisturbed lake. The eggs were therefore exposed to predators, since despite their short flight distances incubating grebes were flushed regularly. Pairs with very short flight distances bred more successfully, which suggests that this behaviour might be adaptive. Overall nesting success, however, was still lower on lakes with recreation than on the undisturbed lake. [author's abstract]

51. KELLER, V. E. 1991. Effects of human disturbance on eider ducklings (*Somateria mollissima*) in an estuarine habitat in Scotland. Biological Conservation 58:213–228.

On the Ythan estuary in Scotland, eider (*Somateria mollissima*) ducklings that roosted on shore or foraged in the water were frequently disturbed by recreational activities. Shore-based activities (anglers, walking people, dogs) caused more disturbances than water-based activities (windsurfers, rowboats). Disturbance affected the activity of eider creches for as long as 35 min. Disturbances of small ducklings increased predator encounters during the 5 min after the disturbance. [from author's abstract]

*52. KELLY, L. M. 1992. The effects of human disturbance mitigation on common loon productivity in northwestern Montana. Pages 246–247 *in* Proceedings from the 1992 Conference on the Loon and Its Ecosystem: Status, Management, and Environmental Concerns, August 22–24, 1992, College of the Atlantic, Bar Harbor, Maine. Maine Audubon Society, Falmouth.

The productivity and the effects of human disturbance on common loons (*Gavia immer*) were studied during 1986–91 in the Tobacco–Stillwater and Clearwater–Swan drainages in northwestern Montana. Anthropogenic disturbance, which included boats and shoreline activities, accounted for 59% of the observed flushing of loons and kept the birds off their nests an average of 24 min/flush. Twelve (52%) of the 23 boats that flushed loons were boats of anglers. Canoes, kayaks, and rowboats also disturbed nesting loons. The average distances at which the loons flushed in response to approaching boats during the 4 weeks of incubation were 129, 121, 91, and 64 m. The author recommends that 3–6 floating signs be placed in a semicircle at 150 m from the nest site. Signs should be left in place 1–3 weeks after hatching to allow the chicks to become strong enough to leave the protected nursery area. [DLY]

*53. KLUKAS, R., J. C. OGDEN, T. HINES, W. B. ROBERTSON, J. A. KUSHLAN, AND H. W. CAMP-

BELL. 1979. American crocodile recovery plan. U.S. Fish and Wildlife Service, Washington, D.C. 35 pp.

The control of indirect disturbances of American crocodiles (*Crocodylus acutus*) by people, although less measurable than direct disturbances, may be important for the regulation of crocodile populations. Remaining crocodile nesting sites are in remote locations, suggesting that crocodiles are less tolerant than alligators of human activities. Crocodiles may have abandoned some otherwise suitable habitats because of the presence of seemingly innocuous human activities such as angling and boating. [DLY]

54. KNIGHT, R. L. 1984. Responses of wintering bald eagles to boating activity. Journal of Wildlife Management 48:999–1004.

This study was of bald eagle (*Haliaeetus leucocephalus*) responses to a single canoe without a motor. Eagles on the ground almost always flew away when approached by canoes (and usually at much greater distances from the disturbances) than eagles in trees. Boaters may adversely affect wintering bald eagles by disrupting feeding, causing unnecessary energy expenditures, and altering social activities that are important to the acquisition of food. To minimize energy loss, eagles may habituate to boaters if human persecution is insignificant. The tendency to flush perched eagles along the Skagit and Nooksack rivers decreased, indicating the birds may have habituated to boaters. The author suggests a restricted-activity zone of at least 450 m from eagles feeding on the ground to prevent disturbance by a single canoe. Along Pacific Northwest salmon-spawning rivers, feeding by eagles is most intense during the early-morning and late-afternoon hours. Boating should be restricted during these periods. [DLY]

55. KNIGHT, R. L., AND S. K. SKAGEN. 1986. Effects of recreational disturbance on birds of prey: a review. Pages 355–359 *in* Proceedings of the Southwest raptor management symposium and workshop. National Wildlife Federation. Washington, D.C.

The effects of recreation (i.e., hunting, angling, boating, rock climbing, etc.) on raptors are reviewed. Recreational disturbance can alter normal raptor activity patterns by (1) altering the distribution of raptors; (2) disrupting nest-attentiveness patterns; (3) causing abandonment of breeding territories; (4) reducing productivity; and (5) affecting foraging. Disturbance of raptors by recreation can be mitigated either completely by denying human access to important raptor habitat or by devising management that permits the coexistence of humans and raptors. Under the second option, spatial or temporal restrictions of recreational disturbances are possible. The authors noted a need for empirical information on the influence of outdoor recreation on raptors. [from authors' abstract]

56. KORSCHGEN, C. E., AND R. B. DAHLGREN. 1992. Human disturbances of waterfowl: causes, effects, and management. U.S. Fish and Wildlife Service Fish and Wildlife Leaflet 13.2.15. 8 pp.

This leaflet is about the effects on waterfowl from the drastic increase in water-based recreation during the last 20 years. The researchers, who attempted to quantify the harm from disturbances on migrating and wintering waterfowl, indicated that frequency of disturbance, number of affected birds, and behavioral modification are greater than most had suspected. On Navigation Pool 7 of the upper Mississippi River, birds may have flown as often as an additional hour each day because of human disturbances. More than 2,500 tundra swans (*Cygnus columbianus*) left their most important feeding area on the upper Mississippi River in response to two small boats. Alternative management that the authors list to minimize human disturbances of waterfowl include (1) increasing the quantity, quality, and distribution of foods to compensate for energetic costs from disturbances; (2) establishing screened buffer zones around important waterfowl roosting and feeding areas; (3) reducing the number of roads and access points to limit accessibility to habitats; (4) creating inviolate sanctuaries; and (5) reducing the sources of loud noises and rapid movements of vehicles and machines. [DLY]

57. KORSCHGEN, C. E., L. S. GEORGE, AND W. L. GREEN. 1985. Disturbance of diving ducks by

boaters on a migrational staging area. Wildlife Society Bulletin 13:290–296.

Disturbances of diving ducks, especially canvasbacks (*Aythya valisineria*), were studied in a major staging area on the upper Mississippi River to determine the frequency of disturbances and possible energetic implications. Power boating and hunting are the two main activities that disturb waterfowl in the upper Midwest. The authors suspect that recreational boating during migrations of waterfowl may reduce the value and effectiveness of staging areas on the upper Mississippi River. [DLY]

58. KRAMER, D. 1986. The effects of recreational activity on wintering wildfowl populations at Priory Park Lake, Bedford. Bedfordshire Naturalist 41:21–26.

The effects of recreation on a small lake (25 ha) were compared before and after zoning. Before the zoning of sailing, a low level of disturbance caused the total or near-total departure of all water birds. Before zoning, some species such as teals (*Anas* spp.) took flight as soon as a single sailboat or dinghy was launched and pochards (*Aythya* spp.) flushed as soon as the craft approached them within approximately 80 m. On days when the birds were left undisturbed, the sizes of flocks increased throughout the day. Some pochards and tufted ducks (*Aythya fuligula*) continued to be disturbed by sailing for several weeks after the refuge zone was in place. [DLY]

59. LERCZAK, T. V. 1991. Observations concerning the behavior of wintering bald eagles as influenced by human activities. Bulletin of the Ecological Society of America 72:172.

Bald eagles were studied at various sites near the confluence of the Illinois and Mississippi rivers in a popular outdoor recreation and fishing area. Barge traffic is also high in this area. With the exception of those birds foraging from ice floes, eagle sensitivity to barges decreased as the season progressed. Disturbance from motorboats decreased with ice cover. Eagles tended to be most sensitive to disturbance while in more natural settings than in areas with more human activity. Human disturbance, therefore, may be a detrimental factor only at certain times and places if the energy used in avoidance flights is a major part of eagle energy budgets. [author's abstract]

60. LIDDLE, M. J., AND H. R. A. SCORGIE. 1980. The effects of recreation on freshwater plants and animals: a review. Biological Conservation 17:183–206.

The effects of boating are discussed in terms of wash, turbulence and turbidity, propeller action, direct contact, disturbance of animals, and pollution from outboard motors and sewage. The wave action by motorized boats can be considerable and cause erosion of plant roots. In heavily used waterways that still had marginal vegetation, the present species had root systems that are difficult to erode. The cutting action of the propeller can remove the upper portions of submergent vegetation. Increased turbidity of waters from boats has often been reported, but the authors found little quantitative evidence to support this. Animals moved away from boats and such moves may have been permanent, depending on the size and nature of the water body and whether there was a refuge. In general, the effects of sailing seem to be much less serious than those of motorized boats, although the authors present little quantitative data in support of this view. [DLY]

61. LOCK, A. R., AND R. K. ROSS. 1973. The nesting of the great cormorant (*Phalacrocorax carbo*) and the double-crested cormorant (*P. auritus*) in Nova Scotia in 1971. Canadian Field-Naturalist 87:43–49.

The daily presence of motorized boats close to great cormorant (*Phalacrocorax carbo*) and double-crested cormorant (*Phalacrocorax auritus*) colonies caused little disturbance unless boaters walked on the island, in response to which the birds left their nests. [DLY]

62. LUTTENTON, M. R., AND R. G. RADA. 1986. Effects of disturbance on epiphytic community architecture. Journal of Phycology 22:320–326.

Microdistributional patterns of attached algal communities under varying disturbance regimes in the upper Mississippi River were compared. Localized physical disturbance, induced by motorized boat traffic and wind-

generated wave action in the main channel, inhibited development of complex attached algal communities. Communities exposed to severe disturbance resembled ones in early stages of colonization and development, whereas less disturbed communities were similar to ones in advanced stages of development. These results demonstrated that turbulence strongly influences the community structure of periphtyon on micro- and macroscale levels. *Cladophora* can at times account for as much as 40% of the total plant biomass in sections of the upper Mississippi River. Thus, as shown in other aquatic systems, the *Cladophora* epiphyte community may be a significant food resource for grazers such as microcrustaceans, insect larvae, and minnows. Low community complexity may limit total available resources because adnate taxa may be more difficult to remove by grazers than loosely attached taxa. [from authors' abstract]

63. MABIE, D. W., L. A. JOHNSON, B. C. THOMPSON, AND R. B. TAYLOR. 1989. Responses of wintering whooping cranes to airboat and hunting activities on the Texas coast. Wildlife Society Bulletin 17:249–253.

The potential effect of selected human recreational activities on movements and activity patterns of whooping cranes (*Grus americana*) in winter territories were determined. The authors note that trends depict increasing recreational use of waterways in the United States, and concern has arisen over effects of recreationists on birds using these areas. As the whooping crane population continues to increase, contact with recreationists will also increase. Disturbance from staged activities (i.e., hunter-outboard, hunter-airboat, airboat) are short-term, but responses of cranes to airboats indicated that changes in use of territories by cranes are possible if airboats are frequently in family-group territories. [DLY]

64. MARINE MAMMAL COMMISSION. 1988. Preliminary assessment of habitat protection needs of West Indian manatees on the east coast of Florida and Georgia. Report of the Marine Mammal Commission in Consultation with its Committee of Scientific Advisors on Marine Mammals. Washington, D.C. 107 pp.

A principal threat to West Indian manatees (*Trichechus manatus*) is boat traffic that makes areas hazardous for animals. Between April 1974 and June 1988, 208 manatees killed by boats were recovered on the East Coast of the United States, almost all in Florida. The most important protected-area systems for manatees on the East Coast are Florida's boat-speed regulatory zones. It is recommended that 22 new boat-speed zones, covering approximately 325 additional km of waterway, be added. In addition, a reduction of the frequency of collisions between manatees and boats in essential manatee habitats is recommended by instituting an operations code for boaters. The code would be implemented through a system of regulated boat-speed zones, education of boaters, and enforcement. The regulations would be reductions of boat speeds where manatees most likely occur to give the animals a chance to avoid oncoming boats and the directing of high-speed boat traffic to areas where manatees least likely occur. [DLY]

65. MARNELL, L., D. FOSTER, AND K. CHILMAN. 1978. River recreation research conducted at Ozark National Scenic Riverways 1970–1977: a summary of research projects and findings. National Park Service, Van Buren, Missouri. 137 pp. plus appendix.

The effects of recreation on unique or endangered plant or animal species are mitigated by two factors: (1) intensive recreational use of the Ozark National Scenic Riverways is limited to approximately 5 months of the year and (2) recreational floaters tend to concentrate in few locations. Although no drastic harm of these species by recreation was identified, studies will continue. [DLY]

66. MATHEWS, G. V. T. 1982. The control of recreational disturbance. Chapter 42. Pages 325–330 *in* D. A. Scott, editor. Managing wetlands and their birds, a manual of wetland and waterfowl management. Proceedings 3rd Technical Meeting on Western Palearctic Migratory Bird Management, Biologische Station Rieselfelder Münster, Federal Republic of Germany, 12–15 October 1982.

Degrees of disturbance of waterfowl differ by activity and were grouped into four main categories: (1) boating that involves rapid

movement and loud noise (motorized boating, water-skiing, etc.); (2) boating that involves movement but little noise (sailing, windsurfing, rowing, canoeing); (3) water-based activities involving little movement or noise (sub-aqua, swimming); and (4) activities carried out largely from the banks (angling, bird watching, etc.). A general rule is that boats must be kept at least 300 m from an area in which waterfowl are to be left undisturbed. Zoning must address the size and shape of a water body. Windsurfing is a growing sport and the frequent rise and fall of sails of capsizing beginners are highly disturbing to birds. The surfers tend to use shallow waters that waterfowl also prefer. [DLY]

67. MATHISEN, J. E. 1968. Effects of human disturbance on nesting of bald eagles. Journal of Wildlife Management 31:1–6.

Nests of bald eagles (*Haliaeetus leucocephalus*) in the Chippewa National Forest were observed to determine whether human activity was a source of disturbance and had measurable effect on nesting success or nest occupancy. Angling, boating, water-skiing, and other recreation occurred almost daily within view of an active eagle nest. This nest was occupied 4 years of 4 and the eagles in this nest successfully reproduced in 3 of those 4 years. However, the effect of recreation on nesting eagles may not be restricted to disturbance of the nest site. Boating and other activities may interfere with food gathering and possibly cause general unrest among an eagle population. Some positive value may accrue from fish mortality caused by anglers, providing an easy food source for scavenging eagles. A hint of this is evidenced by the frequent occurrence of assorted fishing tackle at nest sites. [DLY]

68. MCGARIGAL, K., R. G. ANTHONY, AND F. B. ISAACS. 1991. Interactions of humans and bald eagles on the Columbia River estuary. Wildlife Monographs 115, The Wildlife Society, Washington, D.C. 47 pp.

The authors observed high levels of human activities in foraging areas of bald eagles (*Haliaeetus leucocephalus*) on the lower Columbia River and concluded that boating has the potential of significantly influencing foraging patterns of eagles. Based on these findings, a model of human–eagle interactions in foraging areas was developed. It was suggested that management with temporal and spatial restrictions of human activity in the foraging areas would be most effective. A 400–800 m buffer zone around high-use foraging areas is recommended for the Columbia River estuary. [DLY]

69. MCINTYRE, J. 1977. Spring calls the loons. Minnesota Volunteer 40:22–26.

This popular article is about the disturbance by canoeists of nesting and brooding common loons (*Gavia immer*). When canoeists approach a swimming chick too close, adults defend it by elaborate maneuvers to distract the intruders. After the chicks are 2 to 3 days old, they hide near shore and do not stay with the adults during the defense. When alone, their chances of being taken by underwater predators such as snapping turtles (*Chelydra serpentina serpentina*) or large fishes increase. [DLY]

*70. METCALF, L. 1979. The breeding status of the common loon in Vermont. Pages 101–110 *in* S. A. Sutcliffe, editor. Proceedings of the Second North American Conference on Common Loon Research and Management, 14–16 January 1979, Syracuse, N.Y. Audubon Society of New Hampshire, Meredith.

Historical data indicate the common loon (*Gavia immer*) once bred on Lake Dunmore, on Lake Bomoseen, and in the Mallets Bay area of Lake Champlain. During the past 25 years, no territorial pairs seemingly occupied these areas. During this same period, usage of recreational power boats increased in these areas. [DLY]

71. MICKELSON, P. G. 1975. Breeding biology of cackling geese and associated species on the Yukon–Kuskokwim Delta, Alaska. Wildlife Monographs 45, The Wildlife Society, Washington, D.C. 35 pp.

Motorized boats caused goose families to flee and broods to separate. The separated goslings were susceptible to predation by glaucous gulls (*Larus hyperboreus*). The author suggested that human activities such as boating be restricted on waterfowl nesting and brood-rearing grounds to reduce predation on young birds. [DLY]

72. MORGAN, N. C. 1972. Problems of the conservation of freshwater ecosystems. Pages 135–154 *in* R. W. Edwards and D. J. Garrod, editors. Symposia of the Zoological Society of London 29. The Zoological Society of London, London.

Increasing pressures to use open water for recreation have caused problems in the conservation of habitat and wildlife, particularly near large cities. The increased powerboat traffic on the Broads in England has probably contributed to the decline of plants from mechanical damage, stirring of the mud, and pollution by sewage and waste discharge from boats. Restriction of boating to certain buoyed areas and alternative methods of disposal of wastes are necessary conservation measures. Quantitative data are needed on effects of different recreation types. [DLY]

73. MOSS, B. 1977. Conservation problems in the Norfolk Broads and rivers of East Anglia, England—phytoplankton, boats and the causes of turbidity. Biological Conservation 12:95–114.

Increased turbidity of the water in the Norfolk Broads has been associated with the loss of macrophytes and has been attributed to phytoplankton and to disturbance of sediment by the many boats of visiting tourists and residents. Synoptic surveys of turbidity were done in the navigable waterways of Broadland in summer and winter 1973 and of phytoplankton in summer 1973. The differential distribution of phytoplankton is discussed in terms of nutrient loadings and flushing coefficients of the waterway. Highly significant correlations were obtained between phytoplankton numbers and turbidity in the entire system and in Broads and rivers considered separately. A weak correlation between boat activity and turbidity was noncausative. The authors concluded that increase in turbidity is a function of increased nutrient loading from human activities in the catchment area and that boat disturbance does not contribute significantly to the sustained turbidity. [from author's abstract]

74. MUELLER, G. 1980. Effects of recreational river traffic on nest defense by longear sunfish. Transactions of the American Fisheries Society 109:248–251.

An underwater camera system was designed to record the behavior of male nest-guarding longear sunfish (*Lepomis megalotis*) during periods of boating activity. Boats traveling at slow speeds near nests usually drove males from their nests, increasing the likelihood of egg predation. Boats moving at higher speeds or further from nests caused little or no displacement of males but increased turbidity and possible success of predators. Location of a nest near cover increased the male's ability to protect this nest during repeated surface disturbances. [author's abstract]

75. MUNAWAR, M., W. P. NORWOOD, AND L. H. MCCARTHY. 1991. A method for evaluating the impacts of navigationally induced suspended sediments from the Upper Great Lakes connecting channels on the primary productivity. Hydrobiologia 219:325–332.

The effect of navigationally induced suspended sediments from the Upper Great Lakes connecting channels on the size-fractionated primary productivity was evaluated by the Carbon-14 technique. The method was on-site, rapid, sensitive, and inexpensive and provided dynamic-toxicological information essential for hazard assessment. Enhancement and inhibition of the primary productivity was observed in various parts of the Upper Great Lakes connecting channels. These responses seem to depend on the type of natural plankton and their exposure to various contaminant/nutrient complexes generated by the disturbance of the bottom sediments during the passage of ships. Traditionally, only the inhibition of primary productivity was monitored for toxicity, but it is important also to evaluate the implications of enhancement because they may increase eutrophication and the propagation of nuisance blooms and change intricate food-web interactions. The procedure, adopted in this study for the first time, seems to provide simple and rapid screening of environmental perturbations from navigational activities. [from authors' abstract]

76. OGILVIE, M. A. 1981. The mute swan in Britain, 1978. Bird Study 28:87–106.

In recent years, the mute swan (*Cygnus olor*) population in England has declined. Drainage, navigation, and the increase in the recreational use of power boats have been blamed for this decline. Power boats churn up the water, destroy aquatic plants on which swans feed, and create a less stable substrate for such plants. The authors note that the reduction of vegetation could result in the greater availability of bits of fishing line carrying lead weights that the swans may ingest. Lead poisoning has recently been a major cause of mute swan mortality. [DLY]

77. OLSEN, J., AND P. OLSEN. 1980. Alleviating the impact of human disturbance on the breeding peregrine falcon—public and recreational lands. Corella 4:54–57.

Potential disruptions of peregrine falcon (*Falco peregrinus*) breeding are outlined in this paper. Anglers in slow moving power boats that passed directly beneath a nest created more disturbance than fast moving power boats pulling water-skiers that passed within 50 m of a nest. A ban on angling near nest sites during relevant months is recommended to decrease disturbance. [DLY]

78. OWENS, N. W. 1977. Responses of wintering brent geese to human disturbance. Wildfowl 28:5–14.

This author describes the effects of human disturbance on wintering dark-bellied brent geese (*Branta bernicla bernicla*) in Essex. The use of feeding areas, effects on feeding behavior, and fighting among geese are discussed. Large boats in deep water rarely disturbed the geese. Even when the large boats moved into the estuary, the geese ignored them. Yachts rarely disturbed geese, but small power boats with noisy outboard engines caused them to take flight. Nearly half of all disturbances were caused by small planes and 4%, by small boats. Zonation of coastal areas may soon be required. [DLY]

*79. PARRY, M. L. 1987. Multi-purpose use of waters. Pages 66–71 *in* P. S. Maitland and A. K. Turner, editors. Angling and wildlife in freshwaters. Proceedings of a symposium organized by the Scottish Freshwater Group and the British Ecological Society. University of Stirling, 30 October 1985. (ITE Symposium 19).

The author discusses time and space zoning in relation to compensatory conservation. Variation between seasons in flight distances by mallards (*Anas platyrhynchos*) is also discussed. [DLY]

80. PEDROLI, J. C. 1982. Activity and time budget of tufted ducks on Swiss lakes during winter. Wildfowl 33:105–112.

Dense boat traffic was the major disturbance of tufted ducks (*Aythya fuligula*) in feeding areas of the Bas-lac region in the winter. Frequent storms force commercial fishermen to take in their nets at night, which disrupts the nocturnal feeding of waterfowl and resulted in a population decrease in the region. [DLY]

*81. PLUNKETT, R. L. 1979. Major elements of a 5-year comprehensive plan of research and management for the Great Lakes and northeastern United States populations of the common loon, (*Gavia immer*). Pages 154–162 *in* S. A. Sutcliffe, editor. Proceedings of the Second North American Conference on Common Loon Research and Management, 14–16 January 1979, Syracuse, N.Y. Audubon Society of New Hampshire, Meredith.

This study was conducted to maintain and restore a suitable breeding population of common loons (*Gavia immer*) in the Great Lakes and in the northeastern United States. Management of recreational boating include (1) the protection of nesting and brood-rearing habitat of loons; (2) the restriction of human activities on land or in water immediately adjacent to loon nest sites during the most critical portions of the reproductive cycle (e.g., nest site selection, incubation, and immediately after hatching) by such means as zoning and temporary closures to recreational boating; (3) establishment of approved camping grounds along canoe routes to avoid camping on nesting islands of loons; (4) special programs to alert recreational users of the need to avoid disturbing loons during periods of high human use that coincide with critical periods of the loon (e.g., Memorial Day weekend, which in many areas is during the incubation period, and the July 4th weekend, which is during the period of renesting); (5) distribution of information on loon conservation (at boat launching ramps, marinas, and campgrounds and on inserts in boat licenses

and use permits, etc.) on lakes with heavy recreational use. [DLY]

82. POMERANTZ, G. A., D. J. DECKER, G. R. GOFF, AND K. G. PURDY. 1988. Assessing impact of recreation on wildlife: a classification scheme. Wildlife Society Bulletin 16:58–62.

A classification of the effects of recreation on wildlife was developed to provide an alternative framework for making decisions about the permissibility of various recreational uses of wildlands. The classification scheme was developed as part of a study of recreational-use impacts on U.S. Fish and Wildlife Service national wildlife refuges in the northeastern United States. Six categories were developed that were not mutually exclusive. These categories were: direct mortality, indirect mortality, lowered productivity, reduced use of refuge, reduced use of preferred habitat on refuge, aberrant behavior, and stress. After activities are classified by their anticipated disturbance of wildlife, it will be easier to justify their inclusion or exclusion from a particular site. The classification system may enable wildlife managers to select activities that benefit the public while minimizing disturbance to wildlife. [DLY]

83. REAM, C. H. 1976. Loon productivity, human disturbance, and pesticide residues in northern Minnesota. Wilson Bulletin 88:427–432.

This study was initiated to further document the status of the common loon (*Gavia immer*) population in the Superior National Forest and to evaluate the possibilities that the decline is related to pesticide contamination or to increased human activity in the area. The author concluded that the most important factor of population decline was the increasing number of canoeists in the area. In some lakes, campers occupied almost every island several times a week during the critical early nesting period. Campers usually do not directly destroy loon eggs but leave them susceptible to predators by frightening loons off their nests. [DLY]

84. REESE, J. G. 1977. Nesting success of ospreys in central Chesapeake Bay. Pages 109–113 *in* J. C. Ogden, editor. Transactions of the North American Osprey Research Conference, 10–12 February 1972, Williamsburg, Va. U.S. National Park Service Transactions and Proceedings Series 2.

This paper is a summary of the nesting success of an osprey (*Pandion haliaetus*) population in central Chesapeake Bay. Data collected on nesting, hatching, and fledging rates are compared with data from outside the study area. Discussed are some factors such as food supply, nest site availability, and disturbance that may have an influence on nesting success. Anthropogenic disturbance is increasing annually and is suspected to have a more serious than observed influence on reproduction. Horn blowing, shooting, water-skiing, night lights, fast boats, and seaplanes are sources of considerable disturbance. [DLY]

85. REICHHOLF, J. 1976. The influence of recreation activities on waterfowl. Pages 364–369 *in* M. Smart, editor. Proceedings of the International Conference on Conservation of Wetlands and Waterfowl, Heiligenhafen, Federal Republic of Germany, 2–6 December 1974. International Waterfowl Research Bureau, Slimbridge (Glos), England.

The author discusses the disturbance impact of recreational activities on waterfowl in central, western, and northern Europe. Boats enable recreationists to reach the islands that are favored by nesting waterfowl. Heavy clutch losses are a direct result of boating disturbance. Especially sensitive to passing boats are the clutches of waders, gulls, and terns that are easily detectable by predators, but losses are also high in grebes and some duck species. The first attempts of the pied avocet (*Recurvirostra avosetta*) and of the rare red-crested pochard (*Netta rufina*) to breed on the Inn reservoirs failed because of disturbance from passing power boats and canoes. Further severe losses are caused locally by fast power boats. The power boats' bow wave tips over nests near the fringe of the reeds and free-floating grebe nests. [from author's abstract]

86. ROBERTSON, R. J., AND N. J. FLOOD. 1980. Effects of recreational use of shorelines on breeding bird populations. Canadian Field-Naturalist 94:131–138.

Field studies of the effects on breeding bird communities by the disturbance from recreational use of shorelines were conducted at six

lakes in southern Ontario. The species composition of bird populations in the study area was affected by disturbance. In addition, loon nests were often vulnerable to waves from large watercraft. Nesting successes of common loons (*Gavia immer*) and eastern kingbirds (*Tyrannus tyrannus*) were lower in disturbed areas. [DLY]

*87. RODGERS, J. A., AND H. T. SMITH. 1991. Minimum buffer zone requirement to protect nesting bird colonies from human disturbance. Pages 55–56 *in* D. P. Jennings, compiler. Proceedings of the Coastal Nongame Workshop, Southeast Region, 10–12 September 1991. Gainesville, Florida. U.S. Fish and Wildlife Service, and Florida Game and Fresh Water Fish Commission.

Human disturbance can have significant adverse effects on wildlife, and breeding colonial waterbirds are particularly susceptible because of their high-density nesting habits. Identified adverse effects on eggs, nestlings, and adults include egg and nestling mortality, nest evacuation, nestling weight loss or slower growth, premature fledging, and modified adult behaviors such as prelaying site abandonment. Fifteen species of colonial waterbirds nesting in 17 colonies in northern and central Florida were exposed to four different human disturbance variables (HDV) to determine recommended setback (RS) distances for protecting these birds. Intraspecific and interspecific variations were observed in the flushing response distance to the same HDV. In general, wading birds exhibited greater average flush distances in response to approaching pedestrians than to approaching outboard motor boats. RS distances are recommended for individual species for two HDVs based on the mean (+2SD) flushing distance plus 50 m. In general, RS distances of 125 m for wading birds and 175 m for terns seem adequate for buffering colony sites in Florida from disturbances by pedestrians and outboard motor boats. [DLY]

88. SCHNICK, R. A., J. M. MORTON, J. C. MOCHALSKI, AND J. T. BEALL. 1982. Mitigation and enhancement techniques for the Upper Mississippi River system and other large river systems. U.S. Fish and Wildlife Service Resource Publication 149. 714 pp.

Extensive information is provided on techniques that can reduce or eliminate harm of large river systems from human activities (particularly those from navigation), with special reference to the Upper Mississippi River. These techniques should help resource managers with the establishment of sound river management programs. [from authors' abstract]

89. SCHROEDER, G. J. 1972. Results of a 2-year investigation of the ospreys of northern Idaho. M.S. thesis, University of Idaho, Moscow. 63 pp.

This thesis indicates that human presence is not detrimental to osprey (*Pandion haliaetus*) nesting success unless the birds are molested or prolonged activity occurs in the immediate vicinity of the nest. For example, during a 16.5-h observation of a nest along the Coeur d'Alene River, 77 major disturbances occurred within 100 m of an osprey nest, 57 of which were from power boats. The female left the nest only six times as a result of disturbance. Furthermore, three young fledged from a nest on pilings at the mouth of the St. Joe River, where on weekends hundreds of boats passed close to the nest. [DLY]

90. SKAGEN, S. K., R. L. KNIGHT, AND G. H. ORIANS. 1991. Human disturbance of an avian scavenging guild. Ecological Applications 1:215–225.

To determine the effects of human activities on relations in foraging guilds, the authors examined intraguild dynamics of bald eagles (*Haliaeetus leucocephalus*), American crows (*Corvus brachyrhynchos*), and glaucous-winged gulls (*Larus glaucescens*) that scavenged on spawning salmon (*Oncorhynchus* spp.) in the Pacific Northwest. Examined were several hypotheses that postulate the asymmetric foraging relation of the three guild members and reveal the influence of competition and facilitation in these relations. Spatial and temporal patterns of resource use by the three primary guild members varied with the presence and absence of human activity (i.e., commercial rafts, kayaks, canoes, automobiles, and pedestrians) at experimental feeding stations. Guild theory promotes an understanding of the effects of

human disturbance on wildlife communities. [from authors' abstract]

91. SMART, M. M., R. G. RADA, D. N. NIELSEN, AND T. O. CLAFLIN. 1985. The effect of commercial and recreational traffic on the resuspension of sediment in Navigation Pool 9 of the Upper Mississippi River. Hydrobiologia 126:263–274.

    Addressed are the effects of navigation on the magnitude, duration, and transport of resuspended sediments in a navigation pool in the Upper Mississippi River. Examined were 50 commercial and 16 recreational vessel passages at five different main-channel and adjacent side-channel locations and in one channel in the backwaters. Flow patterns create an active interchange of water and sediment between the main channel and backwater areas. This interchange is essential to the ecological stability of the backwaters. However, backwater areas at many locations are currently oversupplied with sediments; consequently, rates of sedimentation increased. Evaluation of factors that are thought to increase the rates of sediment transport to backwater areas is critical because of potentially significant alteration of vast areas of productive aquatic habitat. One important factor contributing to sedimentation is commercial and recreational navigation. Initial studies indicated that navigation can increase sediment-transport rates in the main channel of the river. [DLY]

92. SOWLS, L. W., AND J. C. BARTONEK. 1974. Seabirds—Alaska's most neglected resource. Transactions of the North American Wildlife and Natural Resources Conference 39:117–126.

    Described are the interrelations of seabirds with other resources, the exploitation of these resources by humans, and the potential problem this creates for seabird populations. Seabirds that nest on cliffs are highly susceptible to disturbance. Close approaches of aircraft, boats, or pedestrians almost always result in a panic flight of birds from cliffs. During incubation and brooding, each occurrence causes the falling of many eggs or young from the cliff. Other chicks and eggs that are temporarily abandoned fall prey to gulls and other predators. [DLY]

93. SPEIGHT, M. C. D. 1973. Outdoor recreation and its ecological effects: a bibliography and review. University College London, England, Discussion Papers in Conservation 4. 35 pp.

    Documented are the ecological effects of outdoor recreation in Britain. Power boating and water-skiing disturbed waterbirds such as great crested grebes (*Podiceps cristatus*) that build floating nests on inland waters. Power boats and sailing craft also disturbed wildfowl in deeper water, especially during July and August when the birds are flightless. Canoes, punts, and row boats, which have shallower draughts, approach closer to the water's edge and therefore particularly disturb nesting waterbirds. Disturbed waterbirds may desert the water bodies that they normally frequent. Birds of open habitats seem to be most susceptible, and the effects of disturbance seem to depend more on the frequency of human presence than on the number of people at any one time. [DLY]

94. STALMASTER, M. V., AND J. R. NEWMAN. 1978. Behavioral responses of wintering bald eagles to human activity. Journal of Wildlife Management 42:506–513.

    The effects of human activity on wintering bald eagles (*Haliaeetus leucocephalus*) in Washington were studied for 2 years. Tolerance to disturbance was determined by analyzing eagle distribution in relation to human activity and by measuring flight distances of eagles from simulated human disturbances. Human activity adversely affected the distribution and behavior of eagles. Distribution patterns were significantly changed, resulting in displacement of eagles to areas with lower human activity. Older birds were more sensitive to disturbances. Flight distances in response to simulated disturbances were longest in water and on gravel bars (i.e., boating, fishing), intermediate on land, and shortest under a vegetation canopy. Eagles became habituated to frequent human activities in a nearby farm meadow. Reduced human interferences, creation of vegetation buffer zones, and establishment of restricted activity zones are recommended for wintering grounds of eagles. [from authors' abstract]

95. STERLING, T., AND A. DZUBIN. 1967. Canada goose molt migrations to the Northwest

Territories. Transactions of the North American Natural Resources Conference 32:367–369.

The authors concluded that banding and boating caused some groups of molting Canada geese (*Branta canadensis*) to desert molt sites. The authors suggest spatial and temporal restrictions of human activities in goose molting areas to compensate for the increase in oil exploration, mining, tourism, canoeing, and angling in northern Canada. [DLY]

*96. STOCKWELL, S. S., AND J. JACOBS. 1992. Effects of lakeshore development and recreational activity on the reproductive success of common loons in southern Maine. Pages 222–234 *in* Proceedings from the 1992 Conference on the Loon and Its Ecosystem: Status, Management, and Environmental Concerns, August 22–24, 1992, College of the Atlantic, Bar Harbor, Maine. Maine Audubon Society, Falmouth.

The study revealed that common loons (*Gavia immer*) are reproducing well on lakes with variable levels of boating activity. However, the study also revealed that the number of loon pairs on lakes decreased as the level of water-related activity increased, suggesting that disturbance already lowered the number of territorial pairs on certain lakes. Recommended boating restrictions, buffers, and public education are presented. [DLY]

97. SWENSON, J. E. 1979. Factors affecting status and reproduction of ospreys in Yellowstone National Park. Journal of Wildlife Management 43:595–601.

Factors of status and reproduction of ospreys (*Pandion haliaetus*) in Yellowstone National Park were studied during 1972–77. Boating had a lesser effect than shoreline use on osprey reproduction. However, nesting success was lower in areas with heavy boating and lowest where boaters also used the shore. Reproduction in undisturbed nests but not in disturbed nests was seemingly sufficient to maintain an osprey population. [DLY]

98. THORNBURG, D. D. 1973. Diving duck movements on Keokuk Pool, Mississippi River. Journal of Wildlife Management 37:382–389.

A study was initiated in 1969 to determine the patterns and causes of local movements of diving ducks on the Keokuk Pool and to relate diurnal activity to hunter harvest and food availability. Human disturbance was the major factor inducing mass movements. Continued harassment by boaters often caused mass flights of diving ducks. Restrictions on boating were recommended. [DLY]

99. TITUS, J. R., AND L. W. VANDRUFF. 1981. Response of the common loon to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. Wildlife Monographs 79, The Wildlife Society, Washington, D.C. 58 pp.

Patterns of recreation that cause the most disturbance to the common loon (*Gavia immer*) in the Boundary Waters Canoe Area were investigated. The study revealed that the common loon adapted well to disturbance from boating. Human use of the area may even be compatible with the loon, particularly if shoreline development and motorized boating are curtailed. The authors did not suggest that these findings are representative of loon responses to other types of disturbance. [DLY]

100. TODD, B. L. 1987. Movement patterns and habitat use of stream-dwelling smallmouth bass. M.S. thesis, University of Missouri—Columbia. 105 pp.

Determined were habitat use by smallmouth bass (*Micropterus dolomieui*) at all times of day and in all seasons, daily and seasonal intrapool and interpool movement patterns and seasonal home range size, and the effects of floods and recreational boaters on smallmouth bass behavior. Of the different types of human activities, canoeing during the spawning season probably had the most effect on smallmouth bass behavior. Nests were not as disturbed by boaters in deeper water than in shallow water. Disturbance from gigging at observed levels probably had little long-term effect on smallmouth bass behavior. However, feeding and habitat-selection routines may be altered in areas with high gigging pressure. Other disturbances such as fishing and swimming probably do not have detrimental effects on smallmouth bass. [DLY]

101. TUITE, C. H., P. R. HANSON, AND O. MYRFYN. 1984. Some ecological factors affecting winter wildfowl distribution on inland waters in England and Wales, and the influence of water-based recreation. Journal of Applied Ecology 21:41–62.

The effects of water-based recreation on the number of wintering wildfowl on inland waters were determined by a chi-squared analysis. The results suggest that wildfowl distribution in winter is affected by water-based recreation but that the effect varies considerably by species of wildfowl. Also, the effects of disturbances substantially varied by type of activity. The most susceptible species to disturbance from recreation were the green-winged teal (*Anas crecca*), the shoveler (*A. clypeata*), and the goldeneye (*Bucephala clangula*), whereas the most tolerant were the mute swan (*Cygnus olor*), the tufted duck (*Aythya fuligula*), the common pochard (*Aythya ferina*), and the mallard (*Anas platyrhynchos*). The greatest reduction of wildfowl numbers in winter was from the presence of angling, sailing, and rowing. [from authors' abstract]

102. TUITE, C. H., M. OWEN, AND D. PAYNTER. 1983. Interaction between wildfowl and recreation at Llangorse Lake and Talybont Reservoir, South Wales. Wildfowl 34:48–63.

Described is part of a 3-year study of the effects of water-based recreation on wildfowl populations. The major emphasis of the study was on localized small-scale alterations in feeding or roosting behavior. Different types of water-based recreation are not equally disturbing to waterfowl. For example, one boat may be as disturbing as many. The authors conclude that to fully investigate the effects of human activities on wintering birds requires a long-term and controlled study. Perhaps the only general conclusion that can be gleaned from localized studies is that, where refuges are available on popular recreational lakes, the adverse effects on birds are not as serious. [DLY]

103. U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE, DIVISION OF REFUGES. 1993. Refuges 2003 Draft Environmental Impact Statement. Washington, D.C. 368 pp.

This document was prepared to guide management of the National Wildlife Refuge System during the next decade and to meet the challenges that face fishes and wildlife and the public's use and enjoyment of them. The proposed action by the U.S. Fish and Wildlife Service reflects a more balanced approach to management of the refuge system and focuses on ecosystem management, wildlife observation and educational activities, and resolution of problems that affect the system. Significantly greater emphasis on nongame species, protection and recovery of threatened and endangered species, planning and protection of unique aquatic ecosystems, research and monitoring of biological communities, and education and interpretive activities of biodiversity are recommended. Nonwildlife-oriented activities are discouraged. [DLY]

104. VERMEER, K. 1973. Some aspects of the nesting requirements of common loons in Alberta. Wilson Bulletin 85:429–435.

Information on the nesting requirements of common loons (*Gavia immer*) in western Canada was gathered. Particular attention was paid to the effects of human disturbance. There was a significant inverse correlation between the number of breeding loons and the amount of human disturbance at lakes. At Jan Lake, 10 of 25 loon nests were washed out by a combination of high water levels and waves from motor boats. [DLY]

105. VOS, D. K., R. A. RYDER, AND W. D. GRAUL. 1985. Response of breeding great blue herons to human disturbance in northcentral Colorado. Colonial Waterbirds 8:13–22.

Reactions of nesting great blue herons (*Ardea herodias*) to human disturbance were studied during 1980–82 at heronries in north-central Colorado. Boats passing the heronry caused minimal responses 92% of the time. Only slow-moving boats or canoes directly under the nest elicited a local response. The authors report that nesting herons become habituated to repeated nonthreatening activities such as anglers boating past a heronry. The authors recommend buffer zones of 250 m on land and of 150 m in water around nesting sites from mid-February through early August. Buoys

can be used to form boundaries around heronries in water. [DLY]

106. WALL, G., AND C. WRIGHT. 1977. The environmental impact of outdoor recreation. University of Waterloo, Ontario, Department of Geography Publication Series 11. 69 pp.

Contaminants from recreational power boating and the effects on the aquatic environment are discussed. The authors report 3.3 g of oxygen are consumed in the oxidation of 1.0 g of oil. Oxygen content of the first few centimeters of a lake can be depleted by this process. A decrease in oxygen decreases phytoplankton production in lakes. In addition, as much as 16 of 160 L of gasoline from outboard motors may be discharged into the water. Fish flesh is tainted at a fuel-usage level of 32 L of outboard motor fuel/4 million L of lake water/season. Lead compounds in gasoline may accumulate in bottom sediments and be toxic to some life forms. [DLY]

*107. WOOD, R. L. 1979. Management of breeding loon populations in New Hampshire. Pages 141–146 *in* S. A. Sutcliffe, editor. Proceedings of the Second North American Conference on Common Loon Research and Management, 14–16 January 1979, Syracuse, N.Y. Audubon Society of New Hampshire, Meredith.

Common loon (*Gavia immer*) populations declined as human activity near nesting and rearing sites increased. Intentional destruction of loons is rare today. Unintentional disturbance of nesting loons by boaters is more common. When a nesting loon flushes off a nest in response to disturbance, it leaves the nest susceptible to predation. A canoe or small boat forces the brood from shoreline cover and into open water where the young can be hit by power boats. Also, boats along the shore drive the broods from good feeding areas, physically exhaust the young, and expose them to additional predation from snapping turtles (*Chelydra serpentina serpentina*) and gulls (*Larus* spp.). Public education is recommended to curtail the disturbance of loons. [DLY]

108. WOODALL, P. F. 1983. A quantitative analysis of some winter habitats of the red-billed teal, *Anas erythrorhyncha*, in Zimbabwe. South African Journal of Wildlife Research 13:41–46.

The authors calculated a disturbance index: Disturbance Index = (Total present disturbance – total present attraction) + (Total past disturbance – total past attraction). Environmental variables in the form of area of water, pH, conductivity, turbidity, benthic and neustic organisms, plant cover, and disturbance index were recorded in winter from 19 dams surrounding Harare. Disturbance factors included human presence, swimming, boating, fishing, shooting, irrigation, watering cattle, artificial feeding, and domestic or pinioned ducks. The factors were ranked 0–3 (nil, slight, moderate, extensive). Univariate analysis revealed that the area of water, pH, and a disturbance index differed between dams with and without red-billed teals (*Anas erythrorhyncha*). Disturbance (ameliorated by large areas of water) seems to be the major variable of the presence or absence of red-billed teals. [from author's abstract]

109. YOUNGMAN, R. E. 1977. Great crested grebes breeding on rivers. British Birds 70:544–545.

The numbers of great crested grebes (*Podiceps cristatus*) have increased markedly in the last decade, and suitable breeding habitat on standing water is probably becoming fully utilized. Therefore, individuals may be moving onto rivers. Some of these rivers are heavily used for recreation. The grebes seem to be remarkably tolerant of pleasure craft that pass within 1–2 m of them on these rivers, which contrasts with the birds' reaction to disturbance on standing water. [DLY]

110. YOUSEF, Y. A., W. M. MCLELLON, AND H. H. ZEBUTH. 1980. Changes in phosphorus concentrations due to mixing by motorboats in shallow lakes. Water Research 14:841–852.

Recreational motorboats with engines of 28–165 hp were operated at three selected lakes in central Florida. A pair of isolation chambers representing aquatic habitats was placed in each lake for control and mixing studies of sediments and the overlying water. Mixing in isolation chambers was performed by small electrical motors connected to two-blade propellers. Agitation of the water column in the mixing stations and inside the isolation chambers increased water turbidities and phosphorus concentrations. The increase in turbidity,

and phosphorus content occurred at a much higher rate than the turbidity decline after cessation of mixing. The increase in phosphorus content could result in an increase in lake productivity as noticed from the increase of chlorophyll-*a* concentrations in mixing stations. The data from this study indicate a substantial increase in turbididty and phosphorus concentrations are possible due to recreational boating on shallow lakes. These effects are significant and should be addressed in water-resource studies. Whether control of boat size or horsepower is required on these types of lakes is not determined. However, the study provides a base for regulatory control to prevent degradation of water quality from propeller-induced mixing and for consideration in waste-load allocation modeling. [from authors' abstract]

111. ZIEMAN, J. C. 1976. The ecological effects of physical damage from motor boats on turtle grass beds in southern Florida. Aquatic Botany 2:127–139.

Seagrasses are a valuable resource that produces food and shelter for important fishes and invertebrates, including commercial and game species. The shallow grass beds are a significant part of the Everglades because many species of wading birds search for small food fishes and for invertebrates on these flats. Thus, the seagrass beds are of great importance in the maintenance of the high levels of productivity of the estuarine and marine areas of the park. Beds of turtle grass (*Thalassia testudinum*) are highly productive but do not recover rapidly from physical disturbance of the rhizome system. In shallow waters, the most common form of rhizome disturbance is from the propellers of motor boats. In turtle grass beds, which are otherwise thriving, tracks from propellers persist from 2 to 5 years. The proportion of fine sediment components is reduced in the sediments from the boat tracks, and the pH and EH are more reduced in the disturbed areas than in the surrounding undisturbed grass bed. Damage of this type is most probable in the shallow passes between islands and keys. These areas also recover the slowest because of the rapid tidal currents in the shallow passes. [from author's abstract]

# Author Index

# Subject Index

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3. An Evaluation of Regression Methods to Estimate Nutritional Condition of Canvasbacks and Other Water Birds, by Donald W. Sparling, Jeb A. Barzen, James R. Lovvorn, and Jerome R. Serie. 1992. 11 pp.
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